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Paper Session I-C - A Proposed Experiment for Generating Fractional Gravity in Space Utilizing the Space Shuttle as a Laboratory

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A PROPOSED EXPERIMENT FOR GENERATING FRACTIONAL GRAVITY IN SPACE UTILIZING THE SPACE SHUTTLE AS A LABORATORY

by

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ABSTRACT

The progressive deterioration of the human body while being exposed to zero gravity is a problem that must be dealt with before humans can ever expect to live and work in space for extended periods of time. The cost of frequent short term missions can be a significant motivator for considering the possibility of longer missions and extended stays in space.

It appears that the problems associated with long terms of weightlessness cannot be resolved within a zero gravity atmosphere, and that the presence of some fractional amount of gravity is necessary. If this is so, then how do we go about determining what this optimum "G" is?

Presently, the only two data points that we have are the full gravity of earth and the zero gravity of space. Is there a fractional gravity, somewhere between these two data points, where these problems do not occur? Do they all occur at the same or at various levels? These and many other questions can only be answered by experiment in a fractional gravity laboratory, which can only exist in a zero gravity environment.

This paper examines a concept that uses the

Space Shuttle to place a fractional gravity laboratory in space, and recommends a feasibility study to determine the problems, hazards, risks, and costs involved to implement such an undertaking.

INTRODUCTION

Some of the basic requirements for a fractional gravity laboratory in space are:

- An environmental control and life support system for at least three people.
- Enough room for moving around freely and exercising.
- A communication and data acquisition system.
- The capability to support work excursions outside the laboratory.
- A system of various size thrusters for maneuvering in and out of a gravity configuration.

To build and launch a laboratory such as this, from scratch, would indeed be a very complex and expensive undertaking. However, if a laboratory that meets these requirements already ex-

ists (The Orbiter) and a system capable of launching this laboratory is in place and operational (The Shuttle) then the fractional gravity laboratory now becomes more attainable.

THE CONCEPT

This experiment consists of placing two Shuttle Orbiters in the same orbit in close proximity to each other so they can work together. They should be positioned so that the open payload bays are facing each other. From this position, a rigid span of a predetermined length is erected from a strongback assembly in the payload bays of each Orbiter. (See figure 1.) The ends of the rigid spans from each Orbiter are then mated to each other. This connection should have a marker/beacon to identify the exact center between Orbiters.

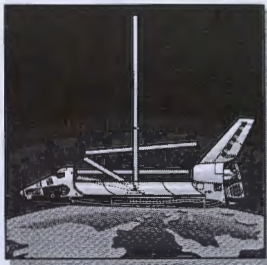


Figure 1.

The Orbiters can now begin to rotate about this marked center of the total span so that the plane of rotation is perpendicular to the path of the orbit. The angular velocity can now be equally

and incrementally increased to produce the fractional gravity selected for the mission. (See figure 2.)

The fractional gravity selected for a mission will restore that same fractional weight to each Orbiter. Consequently, the strongback assembly, rigid span, and attach points will have to be designed to withstand 1.5 to 2.0 times these loads. The payload bay doors will also require special bracing for this type of mission.

THE THEORY

What is involved here is simply an application of the basic principle of centrifugal force. Since the radial acceleration is the product of the angular velocity and the length of the radius of rotation, then different combinations of angular velocities and radial lengths can produce the same acceleration. For example; 1/4 gravity (an acceleration of 8.05 ft/sec²) can be generated with a 50 ft radius by making a complete revolution every 15.659 seconds, or with a 90 ft radius and a full revolution every 21 seconds.

EVALUATION

An evaluation of this proposed experiment should be a feasibility study that includes the following:

1. Perform a stability and controls analysis for all the maneuvers in orbit from deployment through recovery.
2. Prepare a mission requirements document that includes all the requirements that are unique to this type of mission.
3. Prepare a Preliminary Engineering Report (PER) that describes the design require-

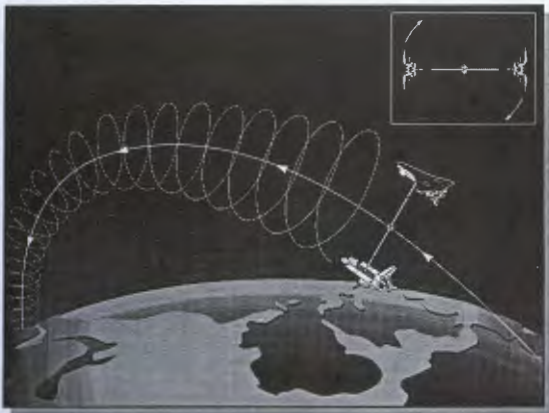


Figure 2.

ments for the rigid span, strongback, attach points, payload bay door supports, and any other support equipment or modifications that may be required.

4. Perform a quantitative risk assessment, mission hazard analysis, and failure modes and effects analysis.
5. Identify problems and hazards for processing and launching two Shuttles within 24 hours of each other, with recommended waivers and acceptance rationale.
6. Identify problems and hazards for two Orbits working in close proximity to each

other, while on-orbit, with recommended waivers and acceptance rationale.

7. Prepare a Cost Benefit Analysis to determine the relative worth of this experiment as opposed to a competing alternative.

CONCLUSION

This fractional gravity experiment could certainly reveal the type of information and data that can provide answers to many of the long standing questions about weightlessness. It may even provide the direction and criteria needed to design long duration missions in space.

In addition to advancing our technology in this area, fractional gravity could be adapted to Space Station through a simple reconfiguration of the habitat modules, and the addition of rigid

spans and thrusters. (See figure 3.) This reconfiguration could have a significant impact on the operation of Space Station by reducing the launch rate required to keep the station manned.

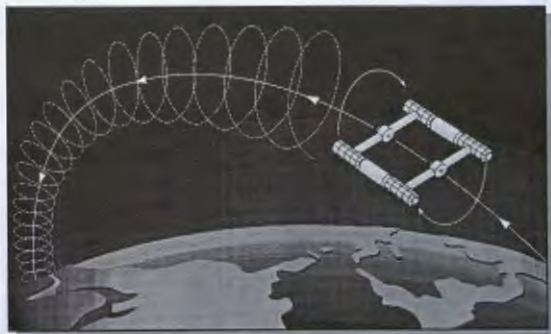


Figure 3.